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Shi et al.

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- (54) **TOWER SUPPORT STRUCTURE** 5,531,419 A * 7/1996 Gustafsson E04H 12/187
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- (71) Applicant: **Ambor Structures, Inc.**, St. Paul, MN (US) 6,925,957 B2 8/2005 Schultz
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- (72) Inventors: **Honglang Shi**, Shanghai (CN); **Xibo Sun**, Shanghai (CN); **Wei Jiang**, Shanghai (CN) 8,240,051 B2 8/2012 Fedock et al.
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- (73) Assignee: **Ambor Structures, Inc.**, St. Paul, MN (US) 8,919,051 B1 12/2014 Echemendia et al.
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- E02D 27/42** (2006.01)
- E02D 27/02** (2006.01)
- E02D 27/08** (2006.01)
- E02D 27/26** (2006.01)

(52) **U.S. Cl.**

CPC **E02D 27/42** (2013.01); **E02D 27/02** (2013.01); **E02D 27/08** (2013.01); **E02D 27/26** (2013.01)

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See application file for complete search history.

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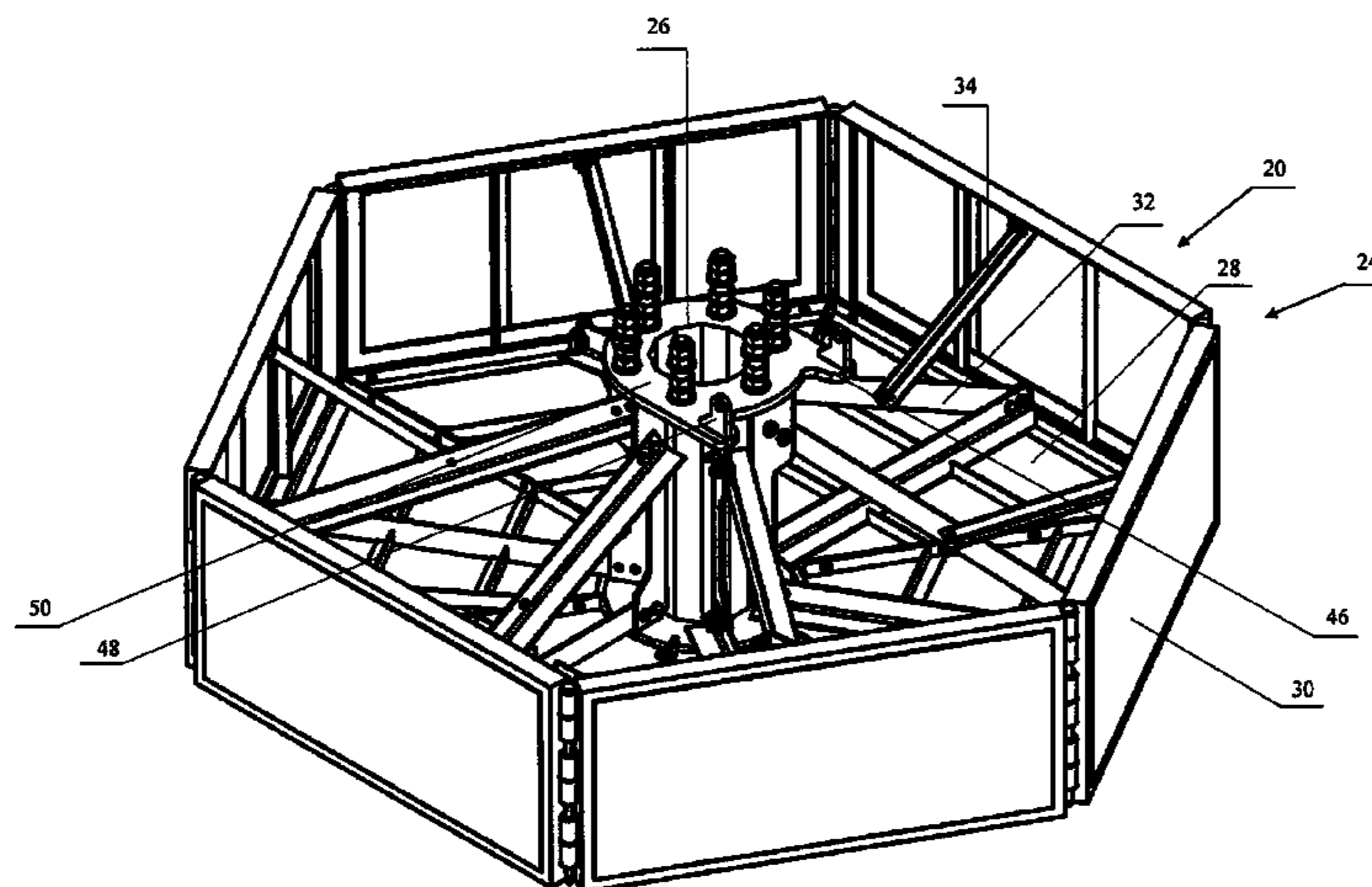
Primary Examiner — Christine T Cajilig

(74) *Attorney, Agent, or Firm* — Patterson Thuente Pedersen, P.A.

(57) **ABSTRACT**

A foundation for a tower, the foundation including a main pedestal support structured to engage to a base of the tower. A floor structure surrounds and is secured to the main pedestal support. A wall structure surrounds the floor structure proximate a perimeter thereof, secured to the perimeter of the floor structure and extending upwardly from the floor structure. The main pedestal support is located generally centrally in the floor structure.

8 Claims, 11 Drawing Sheets



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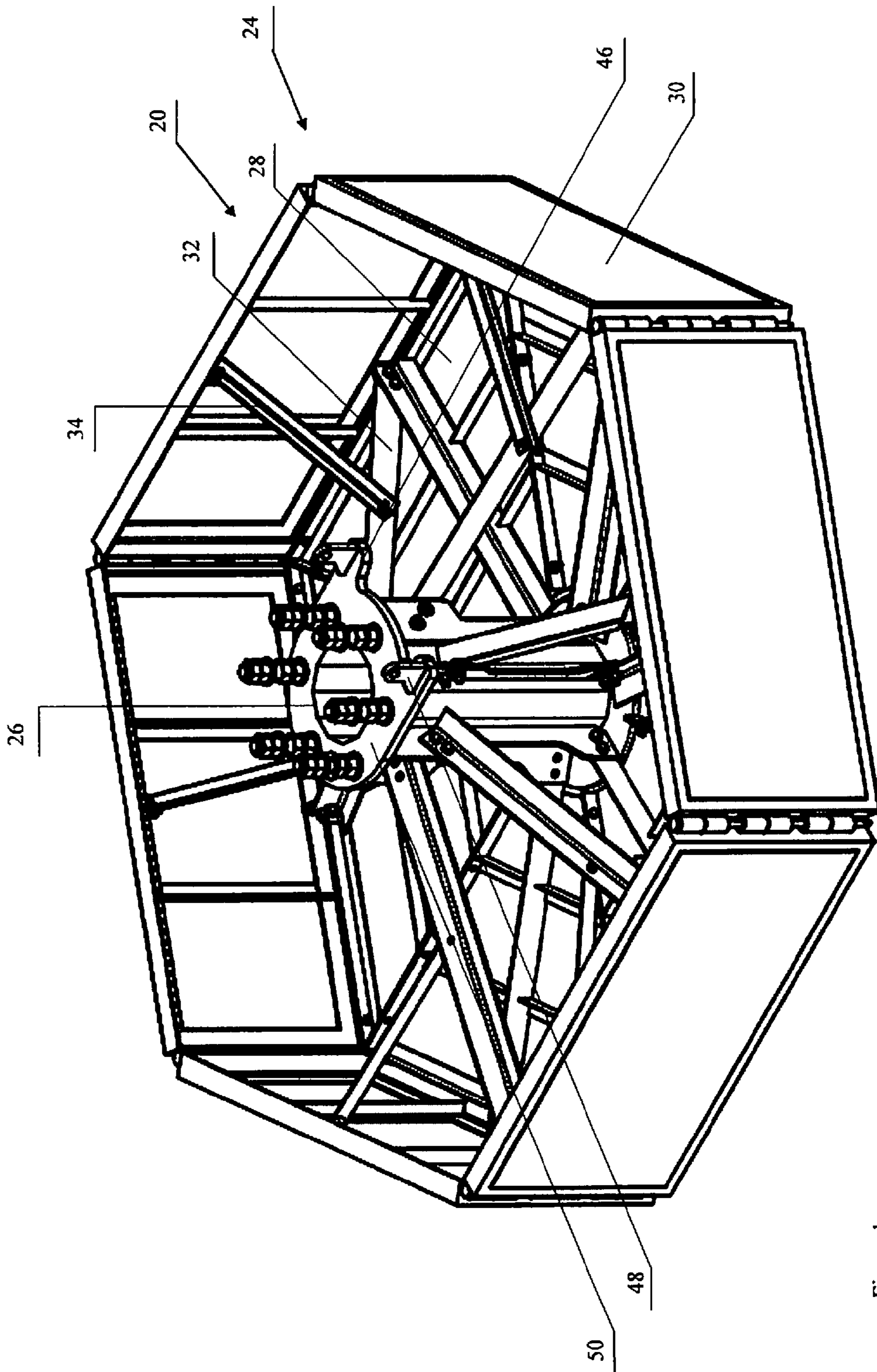


Figure 1

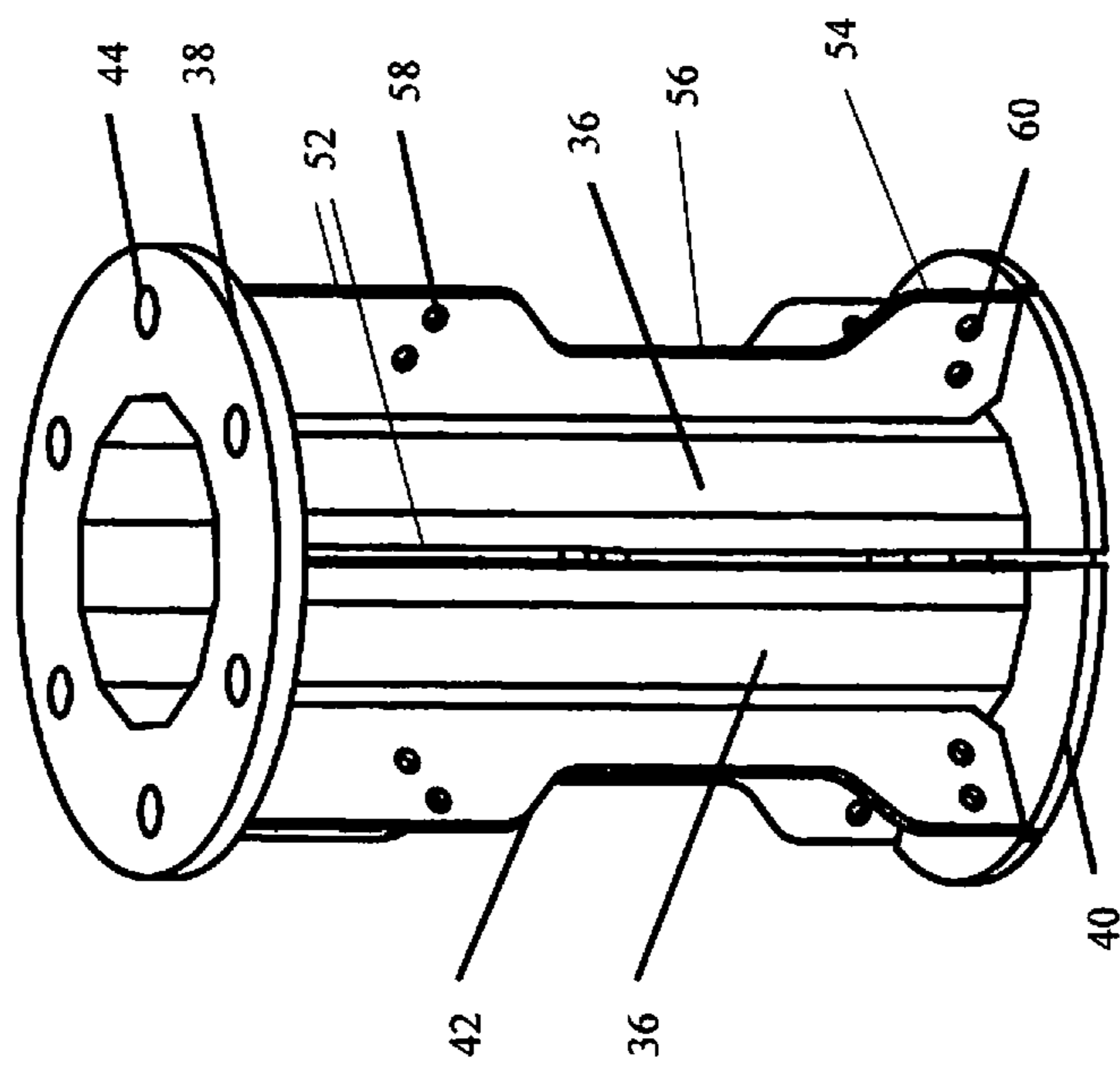


Figure 2

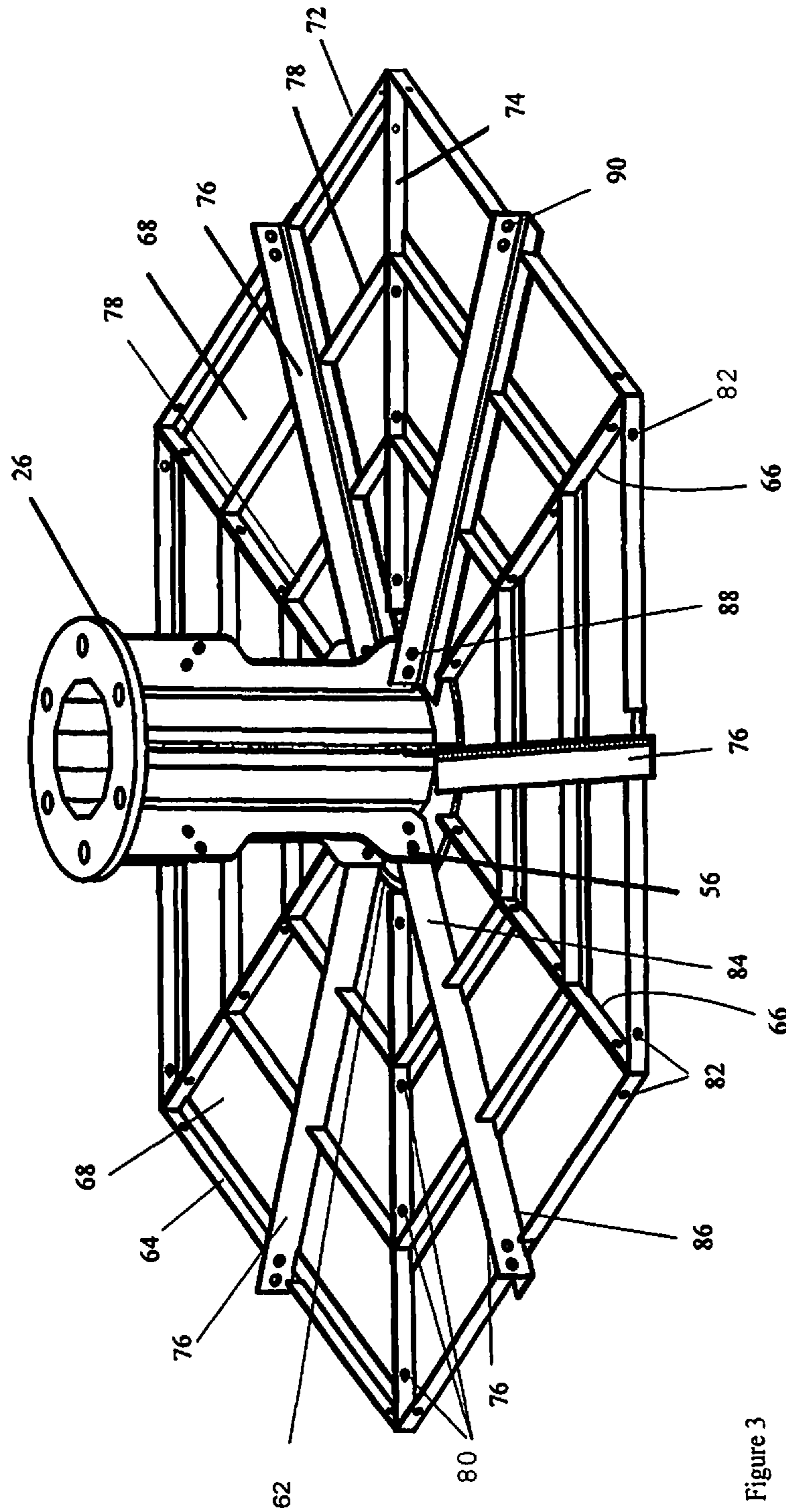


Figure 3

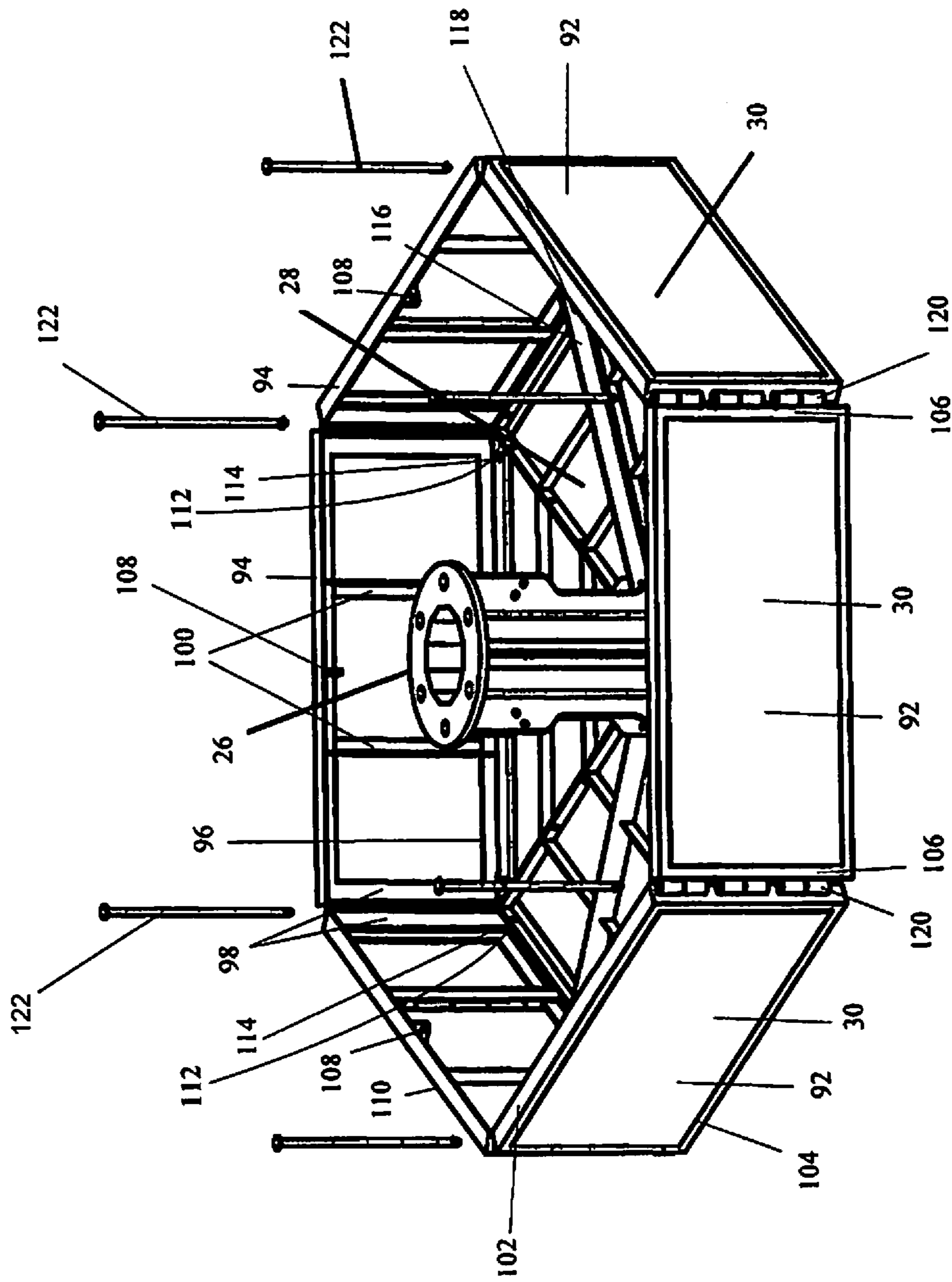


Figure 4

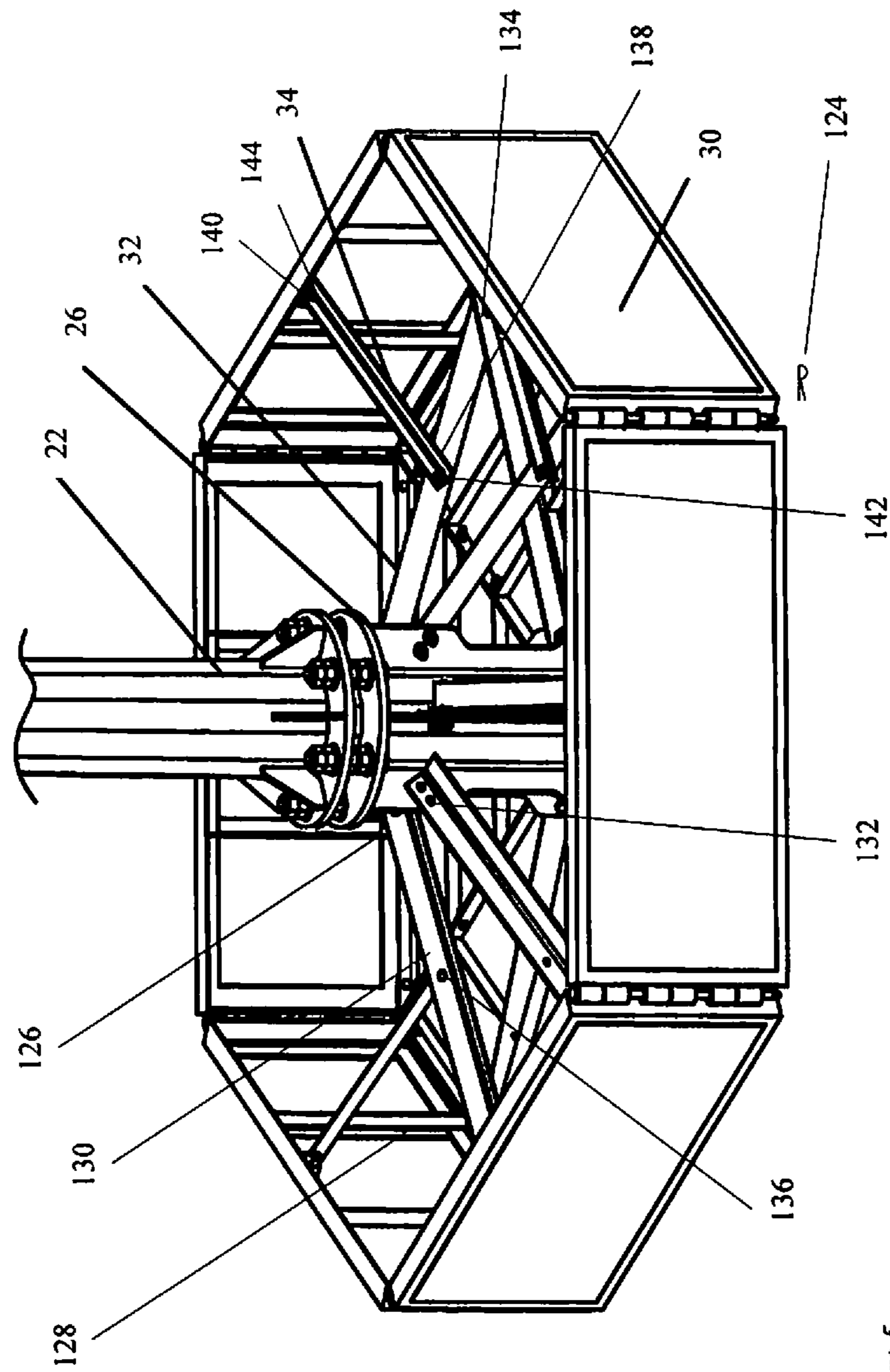


Figure 5

Figure 6

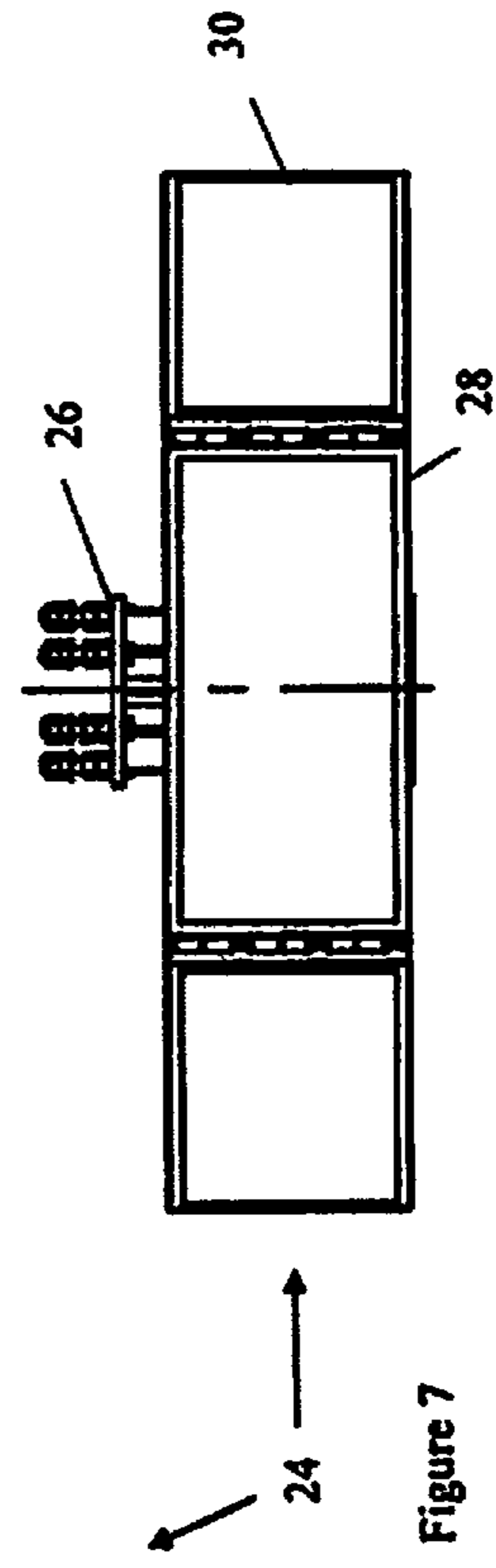
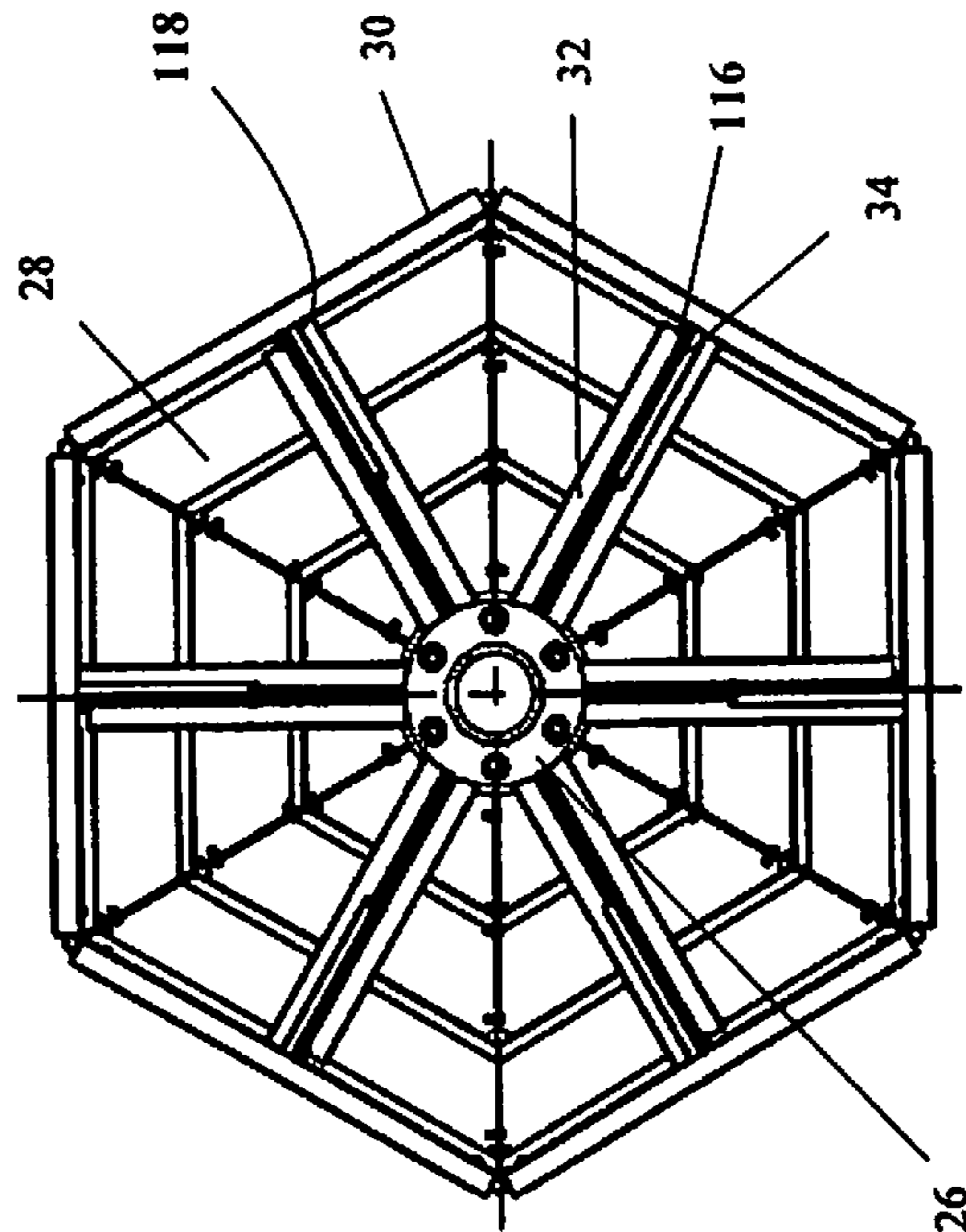


Figure 7

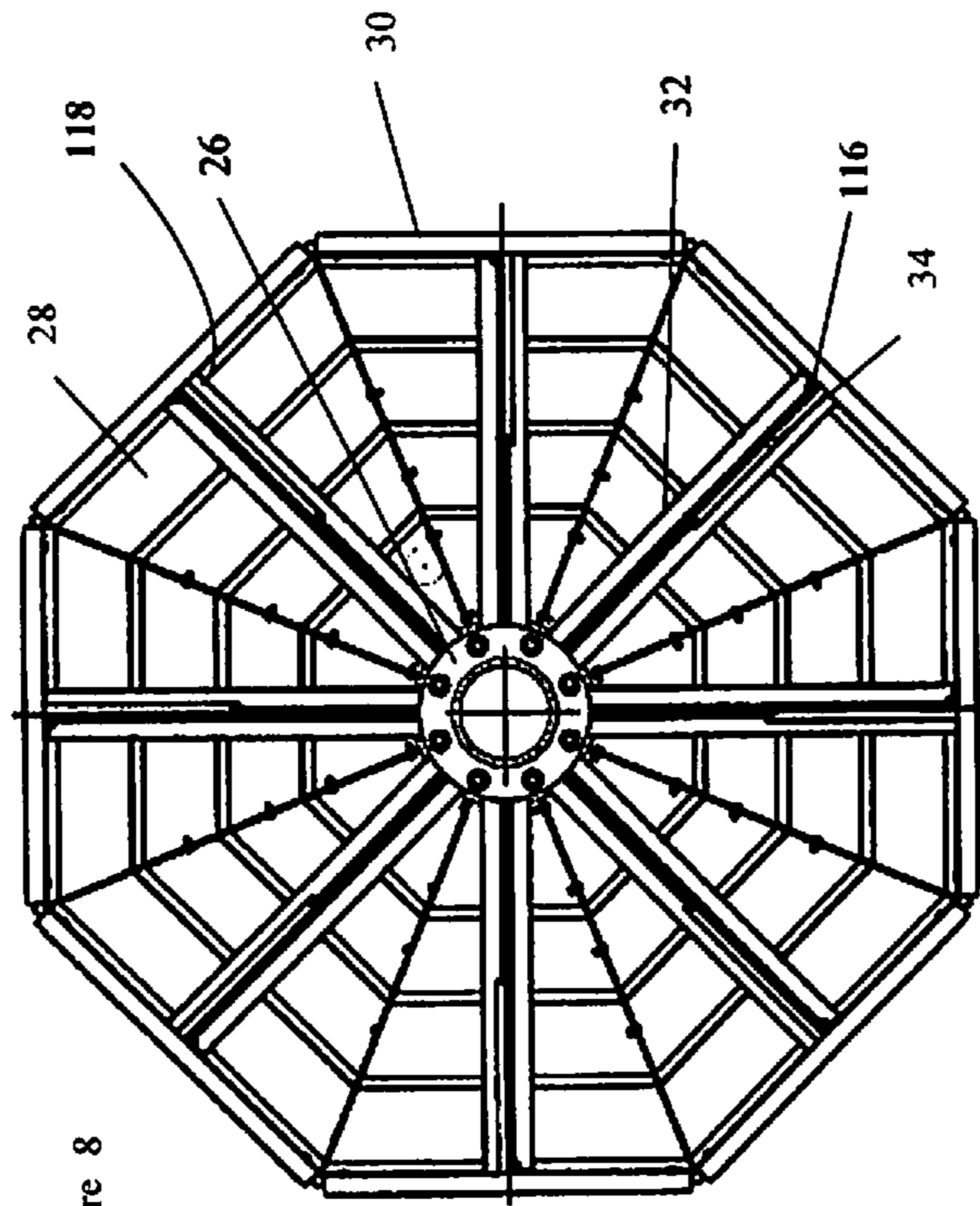


Figure 8

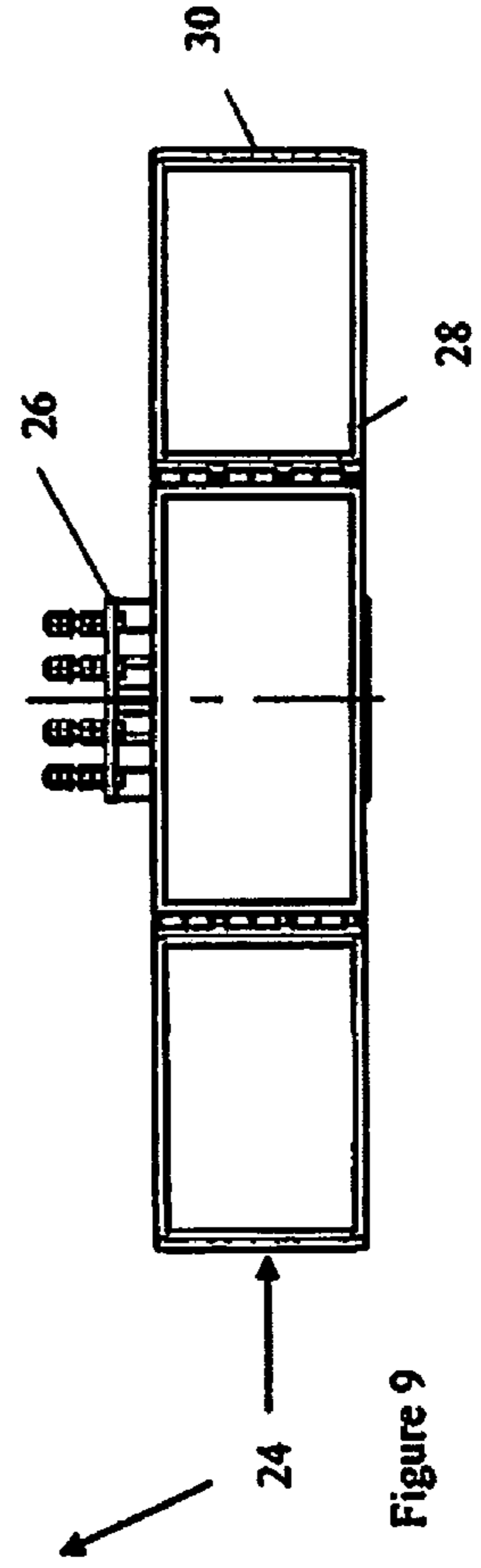
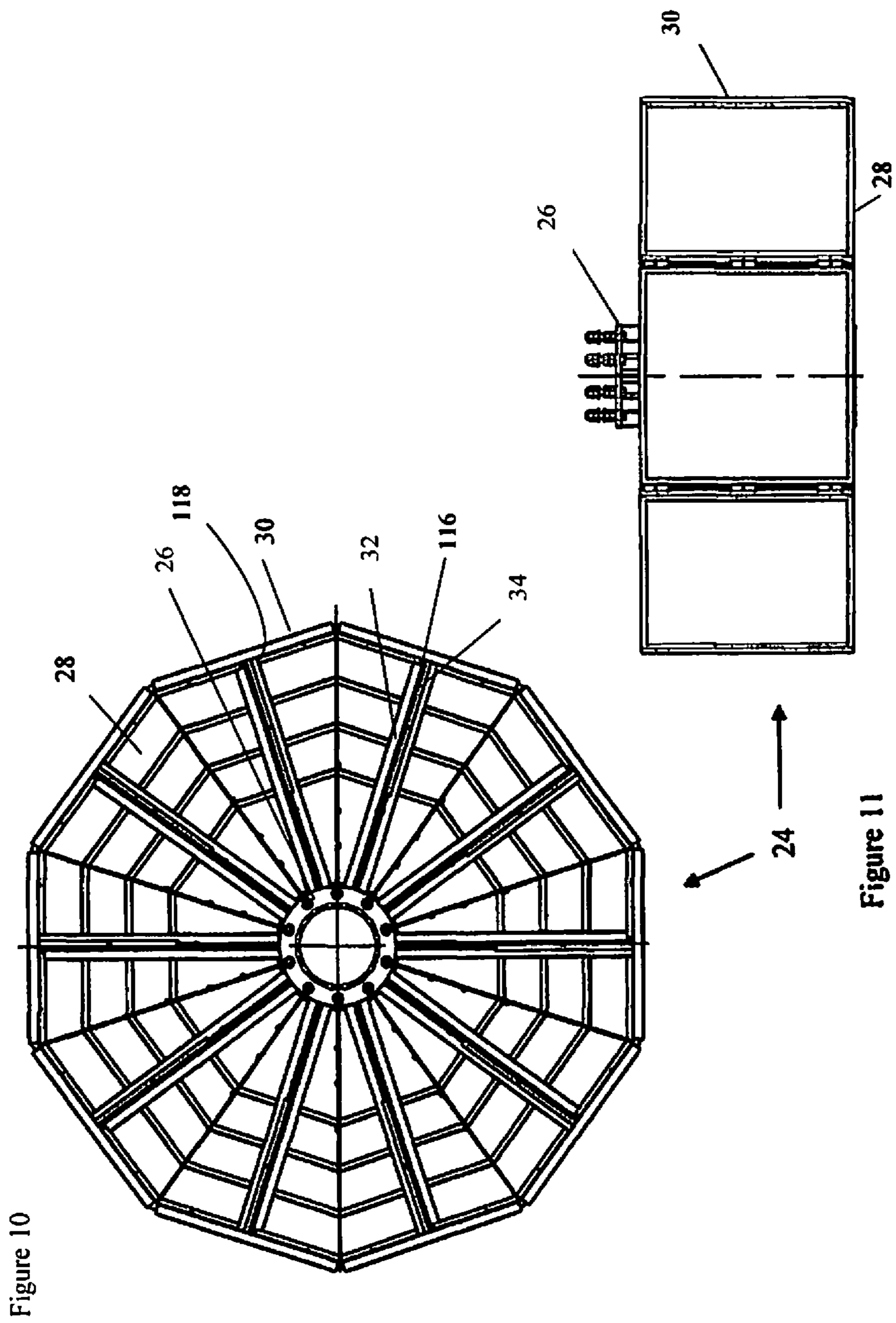


Figure 9



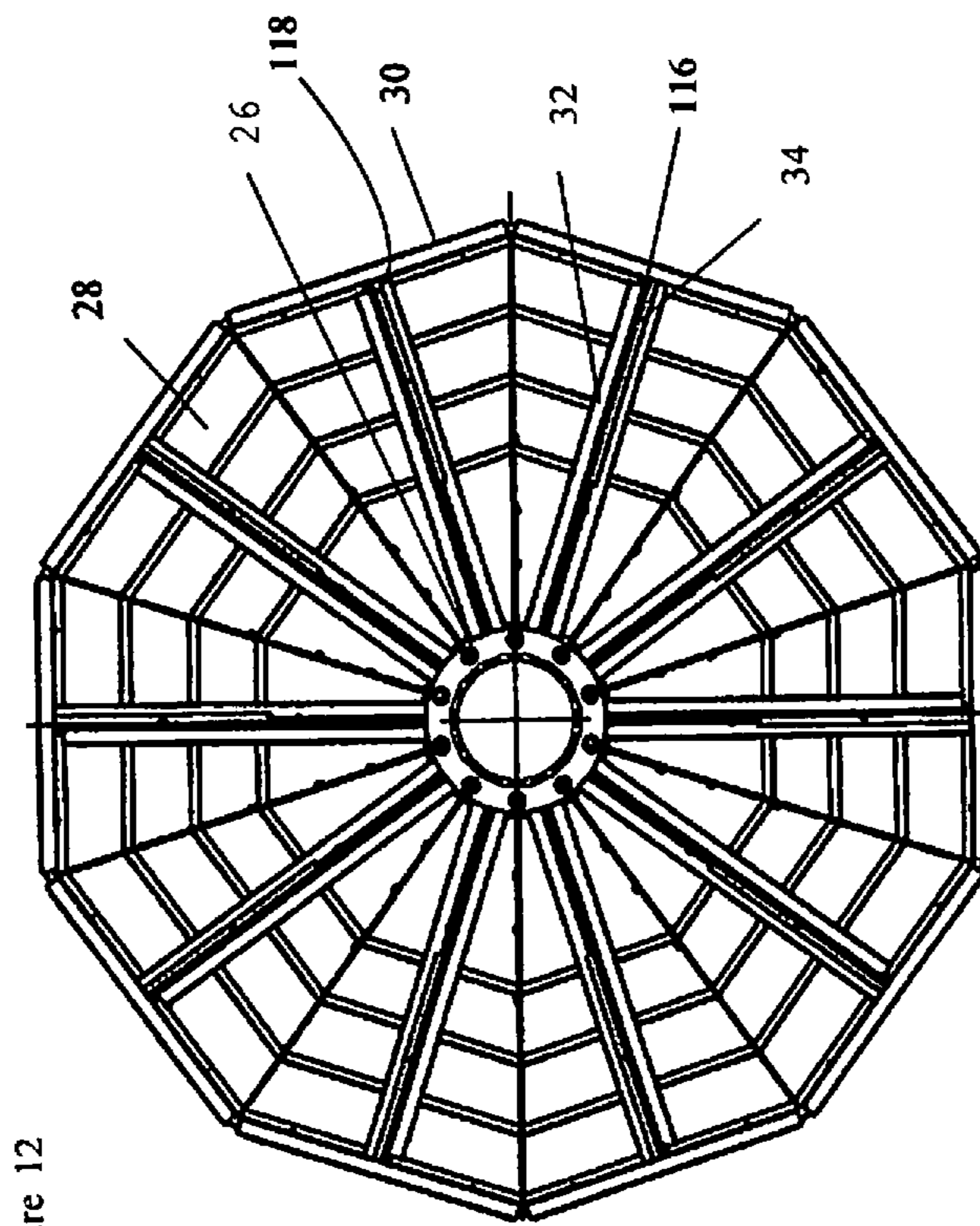


Figure 12

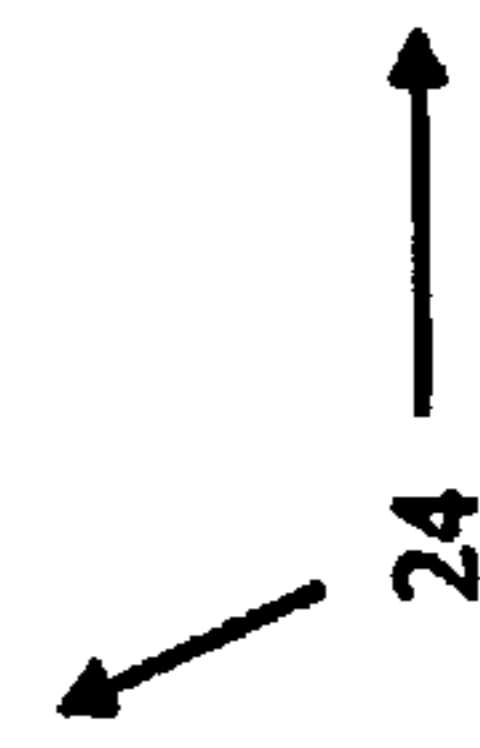
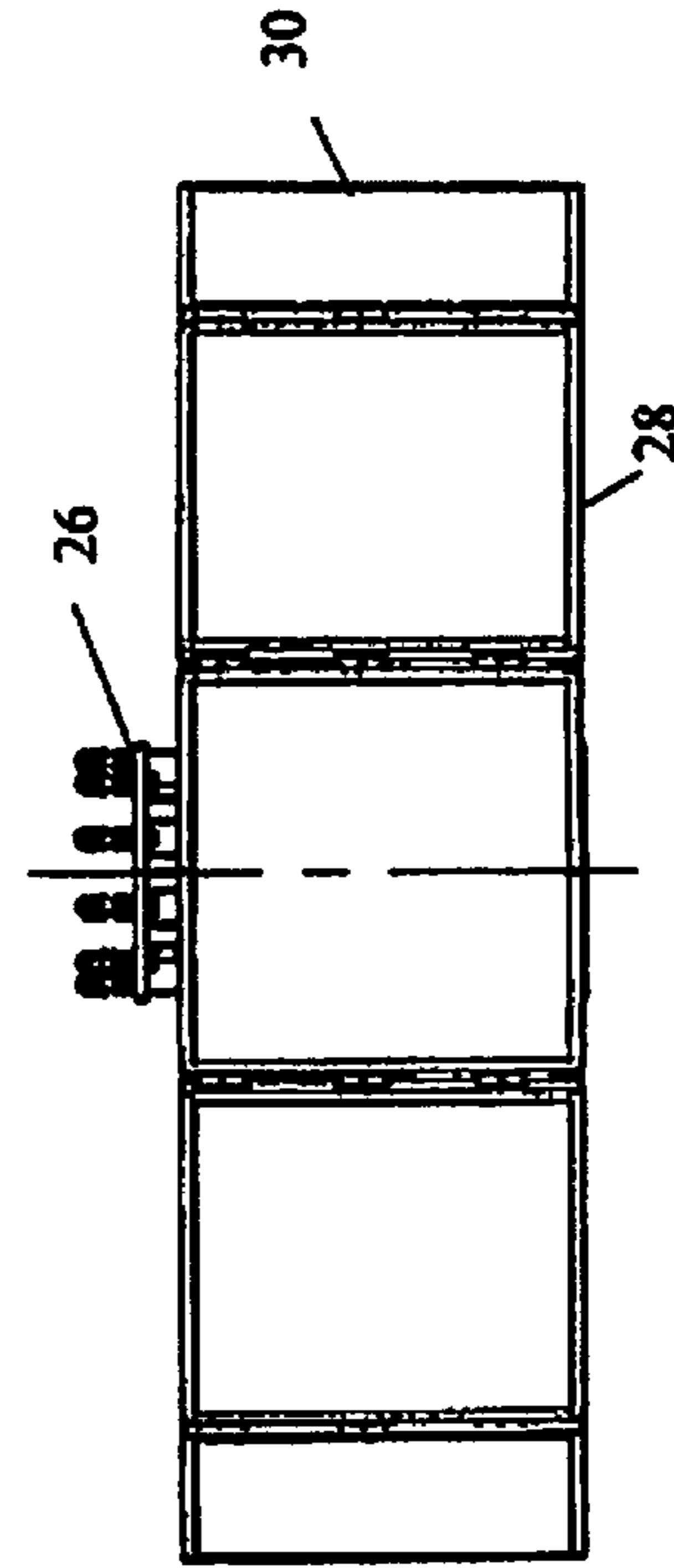


Figure 13

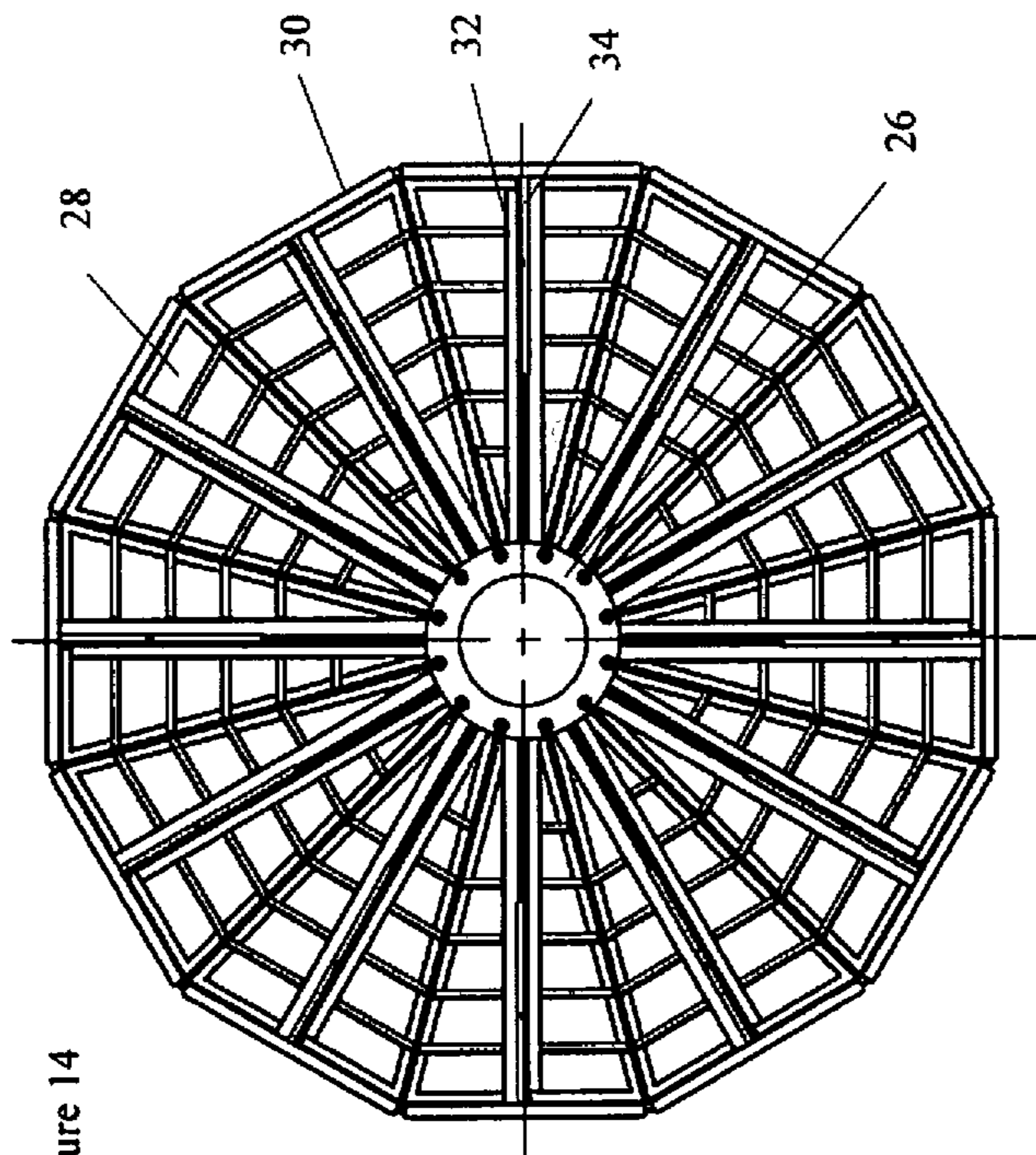


Figure 14

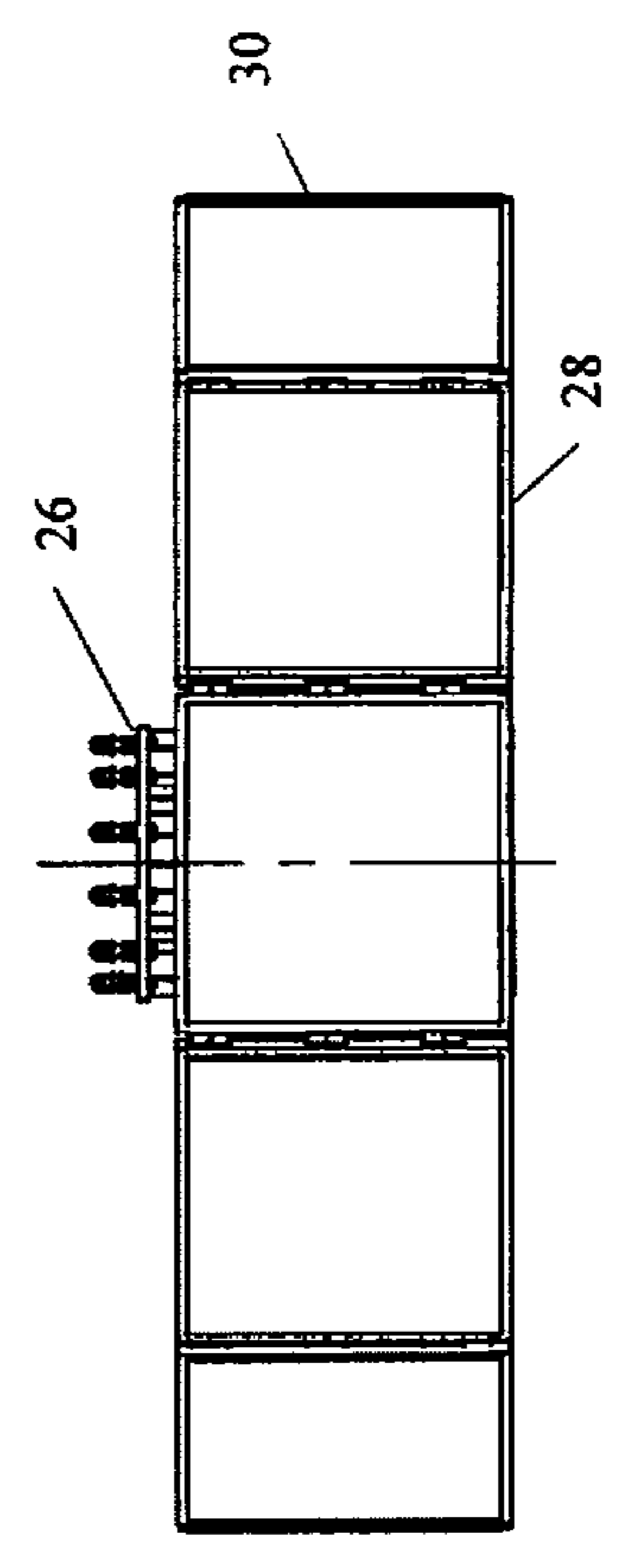
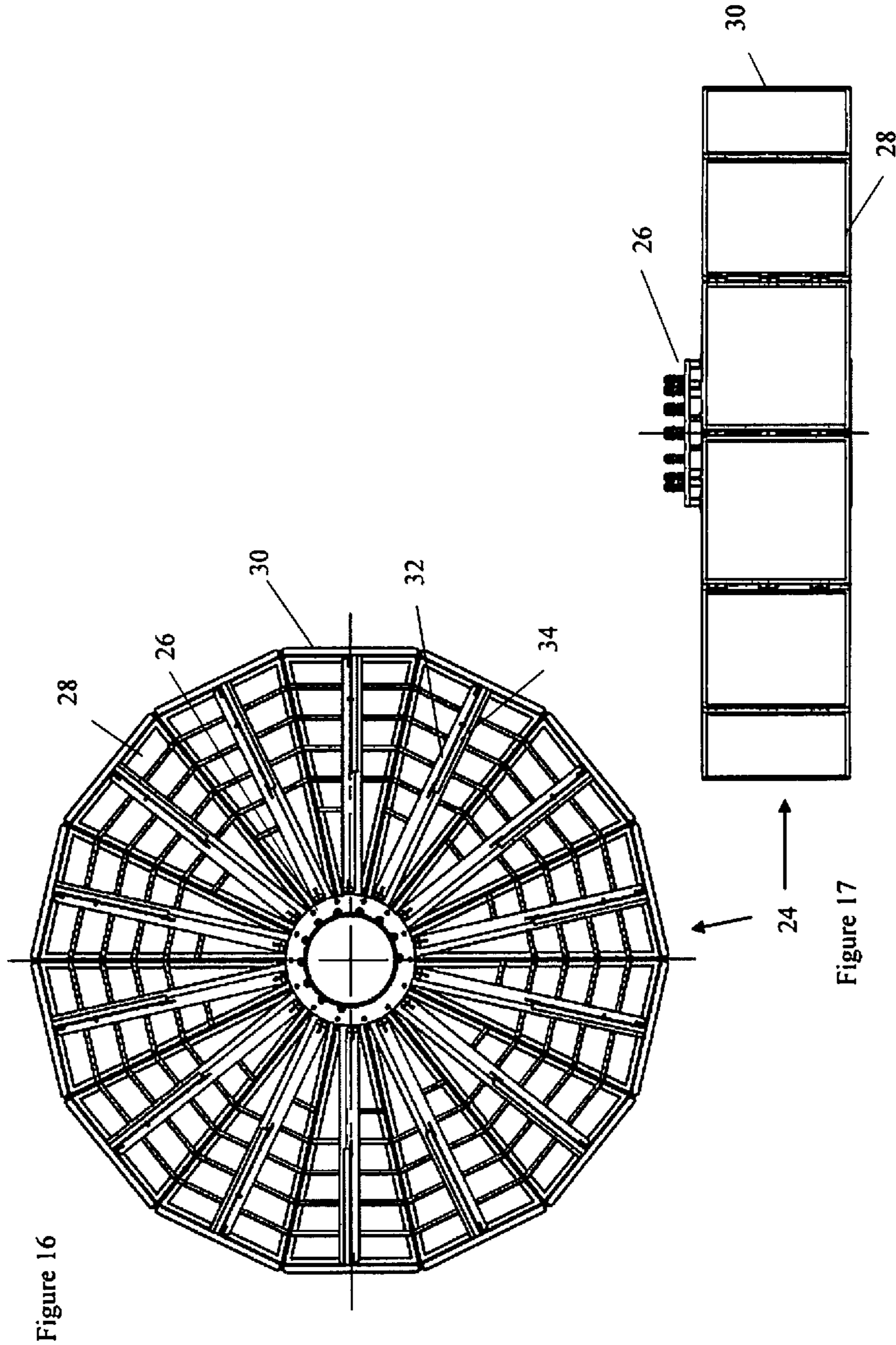


Figure 15



TOWER SUPPORT STRUCTURE

FIELD OF THE INVENTION

The invention generally relates to towers such as communication towers, wind power towers and lighting towers. More particularly, the invention relates to a foundation or support structure for a tower.

BACKGROUND OF THE INVENTION

Towers or other vertical supports are utilized to support many structures such as cell phone antennas, other broadcast antennas, lights, wind power turbines and many other appliances. Towers of any significant height and bearing any significant load must be attached to some form of foundation to keep the tower upright and to resist the forces of wind and weather.

In construction engineering, foundations and foundation designs can vary but commonly use poured concrete and reinforcing rods or reinforcing bars to form a heavy integral structure that is either buried or placed on the ground to support a structure such as a tower. However, the use of concrete foundations is not always convenient or even feasible.

In many of these cases, the use of a concrete foundation is not practical because of limited availability of concrete, long concrete casting and curing times, or the fact that concrete construction creates a large amount of construction waste. For example, materials used for concrete forms often cannot be reused and must be discarded.

Accordingly, there is still room for improvement in the arts related to tower installation and tower foundations.

SUMMARY OF THE INVENTION

The present invention solves many of the above discussed problems by providing a structure that can be fully assembled and disassembled in a short period of time and that permits the utilization of local materials to provide ballast. The foundation structure of the present invention eliminates many of the issues typical to a standard foundation utilized for support structures such as communications towers.

Recent trends have demonstrated a need for temporary, quick to assemble and disassemble foundation on which to mount a tower. A need has also been recognized for a foundation having reduced environmental impact.

For example, after major natural disasters, such as earthquakes, typhoons, tornadoes and tsunamis, there is often a need to rapidly construct temporary structures for lighting, telecommunications and/or security applications. Often, it is necessary to locate these towers or structures in remote locations. Remote locations often have limited accessibility and complex or unfavorable terrain that may make it difficult to transport concrete to a foundation site. Further, the distance from a ready mix concrete plant may make it prohibitively expensive or prohibitively difficult to transport concrete to the construction site.

Even without considering natural disasters or other emergency needs to provide foundations for tower-like structures, growing telecommunications demand has created a need to construct or deploy more tower sites more quickly and thus has created a demand to expedite the process of building a tower site. Wind energy turbine towers are often located far from sources of concrete and may have limited accessibility as well as difficult terrain.

According to an example embodiment of the invention, a tower assembly includes a tower and a base assembly. The tower is generally conventional in structure and will not be described in detail here. The tower may be of a type used to support, for example, cell phone antennas, wind power equipment, lighting or weather monitoring equipment.

The base assembly generally includes a main pedestal support, bottom trays, side support panels, primary support beams and secondary support beams.

The main support pedestal is centrally located within the foundation and includes a vertical cylindrical or polygonal pipe structure having top and bottom plates secured thereto. The top and bottom plates are secured to the cylinder and extend out radially from the top and bottom of the cylinder or polygonal structure. The top plate presents multiple bolt holes typically uniformly spaced around the top plate and located outwardly from the circumference of the cylinder or polygonal tube. The main support pedestal also presents gussets radially disposed around an outer circumference thereof. The gussets are typically evenly spaced around the cylinder or polygonal tube and extend vertically from a top to a bottom of the tubular structure and are bounded by the top plate and the bottom plate.

The bottom trays are secured to the base of the main support pedestal and are arranged generally horizontally around the main support pedestal base. The bottom trays are formed of plates, typically having a polygonal geometry. According to an example embodiment of the invention, the bottom trays are generally trapezoidal in shape having a small end of the trapezoid located centrally and a large end located peripherally. The bottom trays are secured proximate an inner edge thereof to the main support pedestal and proximate an outer edge thereof to the side support panels.

According to an example embodiment of the invention, the side support panels are generally rectangular plate-like structures arranged vertically around an outer circumference of the foundation. The length of each rectangular side support panel is approximately equal to that of the side length of the long side of the bottom trays. The bottom trays are secured to the side support panels. Adjacent side support panels are secured together by a hinge-like connection and a hinge pin thus forming the outer perimeter of the base. The hinge-like connection generally includes mating hinge barrels on the edges of adjacent side support panels. Alternate hinge barrels are secured on each of the mating edges.

According to an example embodiment of the invention, the primary support beams form part of a truss-like support arm. Each primary support beam is secured to the gussets near the top of the main support pedestal. The primary support beams angle downward from near the top of the main support pedestal to the outside of the foundation to be secured with the side support panels and the bottom trays at a juncture thereof.

According to an example embodiment of the invention, a secondary support beam is secured at a first end to approximately the mid-point of the primary support beam and at a second end thereof to a top of a corresponding side support panel.

According to an example embodiment, the base assembly bottom support pallet is formed of the bottom trays. Generally, this forms a regular polygon for example, a regular hexagon assembled from an equal quantity of bottom support trays, side support panels, primary support beams and secondary support beams. In the case of hexagonal assembly, there is six of each of these structures. While the primary example discussed in this application is a hexagonal structure, it should be understood that the invention is not limited

3

to hexagonal structures. The structures may for example be hexagonal, octagonal, decagonal, dodecagonal or tetrade-
cagonal. That is structures according to the invention may
have six, eight, ten twelve or fourteen sides or a larger
number of sides depending upon the involvement. Embodi-
ments having an odd number of sides are also contemplated.

According to an example embodiment of the invention,
the main support pedestal, bottom trays and bottoms of side
support panels are connected together by fasteners such as
bolts. According to an example embodiment, the primary
support beam extends outwardly along the bottom trays to
the respective side support panels and is secured at both the
connection between the bottom trays and the side support
panels and at the gussets near the main support pedestal.
This structural arrangement provides strength and rigidity of
the connection between the main support pedestal and the
bottom trays.

According to an example embodiment, the primary and
secondary support beams may be formed, for example, from
galvanized steel angle. The connection between the primary
support beam and the foundation may be accomplished by
fasteners such as bolts. The bottom trays and side support
panels as well as a primary support beam may be secured by
a single fastener.

The primary support beam may be secured to the gussets
on the main support pedestal near the top flange also by a
bolt or other fastener. The bottom side of each side support
panel is secured to one of the vertical support bars of a
bottom tray and to the other side support panels via a
hinge-like connection. A pin is passed through hinge barrels
of the hinge-like connection to hold each of the side support
panels together with its adjacent side support panel. The pins
are secured in place by an R-type stop pin at the bottom.

Once the base assembly is fully assembled it is filled with
ballast. Examples of ballast that can be utilized include soil,
gravel, bricks, concrete blocks and sand. Of course other
ballast material may be used so long as the material is
sufficiently dense to stabilize the base assembly. The use of
local materials as ballast assists in reducing costs for instal-
lation.

Accordingly, a base assembly in accordance with the
present invention may be utilized to replace a traditional
concrete foundation used for installing self-supporting tow-
ers. The base assembly according to the present invention is
easy to install, easy to handle and may be assembled and
ready for use in a single day. This is a great advantage over
concrete foundations which require significant curing times.
The base assembly of the present invention may be used in
multiple ways including in the ground, above the ground and
may utilize many different types of ballast. The base assem-
bly of the present invention can be disassembled and relo-
cated and can be used for both short term and long term
deployment.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a base assembly according
to an example embodiment of the invention;

FIG. 2 is a perspective view of a main pedestal support
according to an example embodiment of the invention;

FIG. 3 is a perspective view of a main pedestal support
surrounded by six bottom trays according to an example
embodiment of the invention;

FIG. 4 is a partially exploded perspective view of a main
pedestal support, bottom trays and side support panels
according to an example embodiment of the invention;

4

FIG. 5 is a perspective view of an assembled base
assembly including a tower according to an example
embodiment of the invention;

FIG. 6 is a plan view of a hexagonal tower base according
to an example embodiment of the invention;

FIG. 7 is an elevational view of the base assembly of FIG.
6;

FIG. 8 is a plan view of an octagonal base assembly
according to an example embodiment of the invention;

FIG. 9 is an elevational view of the base assembly of FIG.
8;

FIG. 10 is a plan view of an ten sided base assembly
according to an example embodiment of the invention;

FIG. 11 is an elevation view of the base assembly of FIG.
10;

FIG. 12 is a plan view of a ten sided base assembly
according to an example embodiment of the invention;

FIG. 13 is an elevational view of the base assembly of
FIG. 12;

FIG. 14 is a plan view of a twelve sided base assembly
according to an example embodiment of the invention;

FIG. 15 is an elevational view of the base assembly of
FIG. 14;

FIG. 16 is a plan view of a fourteen sided base assembly
according to an example embodiment of the invention; and

FIG. 17 is an elevational view of the base assembly of
FIG. 16.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring to FIGS. 1 and 5, tower foundation 20 accord-
ing to an example embodiment of the invention generally
includes tower 22 and base assembly 24. Tower 22 is
generally conventional in design and can include a mono-
pole tower such as those used to support cell phone trans-
mission antennas, lights or wind power equipment.

Base assembly 24 is a generally basket-like or topless
container structure. Base assembly 24 generally includes
main pedestal support 26, bottom trays 28, side support
panels 30, primary support beams 32 and secondary support
beams 34. Main pedestal support 26 is centrally located and
is surrounded by bottom trays 28. In the depicted example
embodiment, there are six bottom trays 28 and a generally
hexagonal structure. However, this should not be considered
limiting as various embodiments of the invention as depicted
in FIG. 6-16 may have other polygonal structures having
anywhere between six to fourteen sides. Side support panels
30 are arranged around the perimeter of bottom trays 28 and
are secured to one another and are also secured to primary
support beams 32 and secondary support beams 34. Primary
support beams 32 extend generally from main pedestal
support 26 to side support panels 30. Secondary support
beams 34 extend generally from primary support beams 32
to side support panels 30.

Referring particularly to FIGS. 1 and 2, main pedestal
support 26 generally includes tubular member 36, top flange
38, bottom flange 40 and a plurality of longitudinal gussets
42. The number of longitudinal gussets is equal to the
number of bottom trays 28, the number of side support
panels 30, the number of primary support beams 32 and the
number of second support beams 34 according to the
depicted example embodiment.

Tubular member 36 is conveniently formed of a steel tube
having a cylindrical or polygonal cross-section. Tubular
member 36 is conveniently formed of steel tube; however it
may be formed of aluminum tube or another material of
sufficient strength and rigidity. If tubular member 36 is

5

polygonal in cross-section, it is convenient, according to an example embodiment, if the polygon has a number of sides equal to the number of longitudinal gussets 42 or multiple of the number of longitudinal gussets 42.

Referring again to FIGS. 1, 2 and 3, top flange 38 is secured to tubular member 36, for example, by welding. Tower top flange 38 presents tower fastener holes 44 located regularly therein about its perimeter. Tower fastener holes 44 are conveniently located midway between adjacent longitudinal gussets 42. This should not be considered limited however.

Referring to FIG. 1, according to another embodiment, top flange 38 may include tower hinge extensions 46 supporting tower hinge tabs 48. According to the depicted embodiment, tower hinge tabs 48 are pierced by hinge holes 50. Tower hinge tabs are spaced to accommodate tower tabs (not depicted) on tower 22.

Bottom flange 40 is located at an opposing end of tubular member 36 from top flange 38. Bottom flange 40 is generally perpendicular to tubular member 36 and extends radially outward therefrom.

Referring particularly to FIG. 2, longitudinal gussets 42 are evenly spaced about tubular member 36 and extend between top flange 38 and bottom flange 40 according to the depicted embodiment. Longitudinal gussets 42 may conveniently be formed of plate or sheet steel and present upper extension portion 52, lower extension portion 54 and middle portion 56. Upper extension portion 52 is joined to top flange 48 for example by welding. Lower extension portion 54 is joined to bottom flange 40 for example by welding. Upper extension portion 52, lower extension portion 54 and middle portion 56 abut tubular member 36 and may be joined thereto for example by welding. Upper extension portion 52 is pierced by primary support fastener holes 58. In the depicted embodiment, there are two primary support fastener holes 58. However, there may be as few as 1 or more than 2 primary support fastener holes 58.

Lower extension portion 54 is pierced by tray fastener holes 60. In the depicted embodiment, there are two tray fastener holes 60, however, this should not be considered limiting as there may be as few as one or more than two tray fastener holes 60.

Top flange 38 and bottom flange 40 may conveniently be formed of steel plate or sheet. Longitudinal gussets 42 may also be conveniently formed of steel plate or sheet though other materials may be utilized as well so long as they have sufficient rigidity and strength.

Referring particularly to FIGS. 2, 6, 8, 10, 12, 14 and 16, bottom trays 28 in the depicted embodiment are generally trapezoidal-shaped structures. Bottom trays 28 may be conveniently fabricated from sheet steel and steel angle, however, this should not be considered limiting as other materials may be utilized. Bottom trays 28, according to the depicted embodiment, present inner edge 62, outer edge 64 and side edges 66. Inner edge 62 and outer edge 64 are generally parallel and inner edge 62 is shorter than outer edge 64. Side edges 66 are angled relative to inner edge 62 and outer edge 64.

Bottom trays 28 generally include base sheet 68, inner edge angles 70, outer edge angles 72, side edge angles 74, central reinforcement beam 76 and perpendicular reinforcements 78. Inner edge angles 70 are secured to inner edge 62 of base sheet 68 for example by welding. Outer edge angles 72 are secured to outer edge 64 of base sheet 68, for example, by welding. Side edge angles 74 are secured to side edges 66 of base sheet 68, for example, by welding. Side edge angles 74 present adjacent panel fastener holes 80. Side

6

edge angles 74 are pierced by adjacent tray fastener holes 80. Outer edge angles 72 are pierced by side panel fastener holes 82.

Central reinforcement beam 76 extends generally radially through a center of base sheet 68 and extends from inner edge 62 to outer edge 64. Central reinforcement beam 76 extends slightly beyond inner edge 62 and outer edge 64. Central reinforcement beam 76 includes inner end 84 and outer end 86. Inner end 84 is pierced by gusset fastener holes 88. Outer end 86 is pierced by panel fastener holes 90. Perpendicular reinforcements 78 extend in both directions between central reinforcement beam 76 and side edge angles 74. Perpendicular reinforcements 78 are oriented generally parallel to inner edge angles 70 and outer edge angles 72 in the depicted embodiment. Central reinforcement beams 76 and perpendicular reinforcements 78 are conveniently secured to base sheet 68 for example by welding.

Referring particularly to FIG. 4, side support panels 30 are generally rectangular in structure and include side panel plate 92, upper angle 94, lower angle 96, side angles 98 and vertical reinforcement 100. Upper angle 94 is secured to side panel plate 92 at upper edge 102. Lower angle 96 is secured to lower edge 104 of side panel plate 92. Side angles 98 are secured to side edges 106 of side panel plate 92. These structures may all be secured for example by welding.

Vertical reinforcements 100 extend generally vertically between upper angle 94 and lower angle 96.

Upper angle 94 further includes central secondary support tab 108 pierced by fastener hole 110.

Lower angle 96 also includes corner tabs 112 pierced by fastener hole 114 and central primary support tab 116 pierced by fastener hole 118.

Side edges 106 also include hinge barrels 120 secured to an outer portion thereof. Hinge barrels 120 are sized and structured to receive hinge barrels pins 122 therethrough. Hinge barrel pins 122 are structured to accept R clip 124 at an end thereof.

Referring particularly to FIG. 1, primary support beams 32 generally include inner end 126, outer end 128 and central portion 130. Inner end 126 is pierced by gusset fastener holes 132. Outer end 128 is pierced by lower panel fastener holes 134. Central portion 130 is pierced by central beam fastener holes 136.

Secondary support beams 34 generally include inner end 138 and outer end 140. Inner end 138 is pierced by primary support fastener holes 142. Outer end 140 is pierced by panel fastener holes 144.

Primary support beams 32 and secondary support beams 34 may be fabricated from steel angle or other sufficiently rigid material.

In operation, tower foundation 20 is placed on a prepared area. The prepared area is leveled prior to installation for example by placement of an aggregate and leveling the aggregate prior to installation.

Main pedestal support 26 is placed centrally on the leveled prepared area. Bottom trays 28 are positioned around main pedestal support 26 with inner end 84 of central reinforcement beam 76 located adjacent to lower extension portions 54 of longitudinal gussets 52.

Once bottom trays 28 are all located, fasteners such as bolts (not shown) may be utilized to secure inner end 84 of central reinforcement beam 76 to lower extension portions 54 of longitudinal gussets 42. Bottom trays 28 may be secured to each other by the application of fasteners through adjacent tray fastener holes 80. Side support panels 30 are secured to bottom trays 28 by application of fasteners through outer edge angles 72 through corner tabs 112. Side

support panels **30** are secured to each other by aligning adjacent hinge barrels **120** and inserting hinge barrel pins **122** through hinge barrels **120**. Hinge barrel pins **122** are then secured by the application of R clips **124** at a lower end thereof. When all side support panels **30** are in place, primary support beams **32** are installed.

Primary support beams **32** are installed by coupling inner end **126** to upper extension portion **52** of longitudinal gussets **42** and outer end **128** to central primary support tab **116** at the lower edge of side support panels **30**. Secondary support beams **34** are secured at inner end **138** to central portion **130** of primary support beams **32**. Outer ends **140** of secondary support beams **34** are secured to central secondary support tab **108** of side support panels **30**. All fasteners are then secured tightened.

The interior of base assembly **24** is then filled with ballast such as soil, gravel, bricks, concrete blocks or other locally available ballast.

Tower **22** is then secured to main pedestal support **26** via top flange **38**. Tower **22** is typically secured to top flange **38** via bolts.

In the embodiment where tower hinge tabs **48** are present, tower hinge tabs **48** are secured to a base of tower **22** via similar tabs (not shown) on tower **22**. Tower **22** may then rotated from a horizontal position to a vertical position and secured by fasteners.

The present invention may be embodied in other specific forms without departing from the spirit of the essential attributes thereof therefore, the illustrated embodiments should be considered in all respects as illustrative and not restrictive, reference being made to the appended claims rather than to the foregoing description to indicate the scope of the invention.

The invention claimed is:

1. A foundation for a tower, the foundation comprising:
a main pedestal support structured to engage to a base of the tower;

a floor structure surrounding and secured to the main pedestal support, the floor structure comprises a plurality of bottom trays;

a wall structure surrounding the floor structure proximate a perimeter thereof, secured to the perimeter of the floor structure and extending upwardly from the floor structure, the wall structure including a plurality of side support panels;

wherein the main pedestal support is located generally centrally in the floor structure and the floor structure and the wall structure together form an open topped structure into which ballast may be placed;

wherein the main pedestal further comprises a tubular structure including longitudinal gussets extending vertically along a length of the tubular structure from a top flange to a bottom flange of the main pedestal support and the longitudinal gussets extending radially outwardly from the tubular structure;

wherein each of the plurality of bottom trays further comprises a base sheet and a central reinforcement beam, the central reinforcement beam extending across and over a top of the base sheet and being structured to couple to one of the longitudinal gussets of the main pedestal support at a first end thereof and being structured to couple to one of the plurality of the side support panels at a second end thereof;

wherein each side support panel comprises hinge barrels along sides thereof, the hinge barrels being configured to rotatably engage to hinge barrels of an adjacent side panel and to receive a hinge pin therein.

2. The foundation as claimed in claim **1**, wherein the top flange is configured to engage the base of the tower.

3. The foundation as claimed in claim **1**, wherein each of the bottom trays is generally trapezoidal in shape.

4. The foundation as claimed in claim **1**, further comprising a plurality of primary support beams, each of the primary support beams being secured to the main pedestal support at a first end thereof and secured to the floor structure, the wall structure or both the floor structure and the wall structure proximate the perimeter of the floor structure.

5. The foundation as claimed in claim **4**, further comprising a plurality of secondary support beams each of the secondary support beams being secured to one of the primary support beams at a first end of the secondary support beam and to the wall structure at a second end of the secondary support beam.

6. A method of preparing a foundation for a tower structure, the method comprising:

placing a main pedestal support on a generally level surface, the main pedestal support comprising tower coupling members that are coupleable to the tower structure;

locating a plurality of bottom trays surrounding and in contact with a base of the main pedestal support;

locating a plurality side support panels at a perimeter of the bottom support trays, each of the side support panels being in contact with at least one of the bottom trays;

securing at least some of the bottom trays to the main pedestal support;

securing at least some of the side support panels to at least some of the bottom trays;

securing a tubular structure of the main pedestal support to the plurality of bottom trays via longitudinal gussets extending vertically along a length of the tubular structure from a top flange to a bottom flange of the main pedestal and radially outwardly from the tubular structure and primary support beams;

coupling each of the bottom trays to a central reinforcement beam, the central reinforcement beam extending across and over a top of the base sheet;

coupling the central reinforcement beam to the main pedestal support at a first end thereof;

coupling the reinforcement beam to one of the side support panels at a second end thereof; and

coupling each side support panel to an adjacent side support panel by engaging hinge barrels of adjacent side support panels and rotatably securing the adjacent side support panels to each other by inserting hinge pins through the hinge barrels.

7. The method as claimed in claim **6**, further comprising leveling the generally horizontal surface prior to placement of the main pedestal support.

8. A foundation for a tower, the foundation comprising:
a main pedestal support having a tower engaging portion structured to engage to a base of the tower, the main pedestal support being secured to a basket structure having a floor and perimeter walls;

wherein the basket structure is fillable with loose granular ballast and the main pedestal includes a tubular structure having longitudinal gussets extending vertically along a length of the tubular structure from a top flange to a bottom flange of the main pedestal support and radially outwardly from the tubular structure;

wherein each of a plurality of bottom trays further comprises a base sheet and a central reinforcement beam, the central reinforcement beam extending across and

over a top of the base sheet and being structured to couple to the gussets of the main pedestal support at a first end thereof and being structured to couple to a side support panel at a second end thereof; and
wherein each side support panel comprises hinge barrels 5
along sides thereof, the hinge barrels of a first side support panel being configured to rotatably engage to the hinge barrels of a second adjacent side support panel and to receive a hinge pin therein.

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